

THE BREEDING BIOLOGY OF BARN AND CLIFF SWALLOWS IN WEST VIRGINIA

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BARN Swallows (*Hirundo rustica*) and Cliff Swallows (*Petrochelidon pyrrhonota*) both nest in parts of the eastern United States. The colonial Cliff Swallow nests under bridges or dams, on the outside of barns, and inside open sheds and barns. Barn Swallows nest inside such sheds and barns during the same time interval. Both build a mud nest, the Barn Swallow's cup-shaped and the Cliff Swallow's gourd shaped. Barn and Cliff Swallows are insectivorous, may feed in the same flock, perch together, and occasionally nest in the same building. Hybridization might be anticipated but only two instances have been reported (Mearns, 1902; Bent, 1942).

I wanted to determine: if temporal separation of breeding season occurred as suggested by Moody (1968); if spatial separation occurred at the nesting site; if there was feeding or perching stratification; and if distinct foraging areas existed.

METHODS

This study covered the summers of 1967 and 1968, and was made in 11 barns and five sheds near Bruceton Mills in Preston County, West Virginia. Visits were made to all barns at least every other day. Additional observations were made in four barns near Cranesville Swamp, Preston County, West Virginia, and in one barn in Jefferson County, Ohio. Cultivated fields and patches of hardwood forests made up all study areas. Temperature data were collected on the Bruceton Mills study area using a 7-day thermograph. Data for Cranesville Swamp were from the government station near Terra Alta. Birds were mist-netted, paint-marked, and sexed (Samuel, 1969a and 1971).

RESULTS

Arrival.—Barn Swallows arrived earlier than Cliff Swallows (Figs. 1 and 2). The arrival time varied for Barn and Cliff Swallows from barn to barn and year to year. For example, Barn Swallows arrived at different barns on study area A on 6 April, 16 April, 20 April, and 21 April in 1968. Both species arrived during or immediately after a few days of warm (usually 70°) weather (Fig. 3).

Three dead adult Barn Swallows were found during relatively cold weather (Fig. 3). Six of 10 birds present were marked at a barn on study area A during 20–25 April, 1967. By 28 April none were in the area, but only one was found dead. New arrivals moved into the same barn on 2–4 May and began nesting activities.

Estimated Nesting Populations.—All active nests were counted to estimate

1967

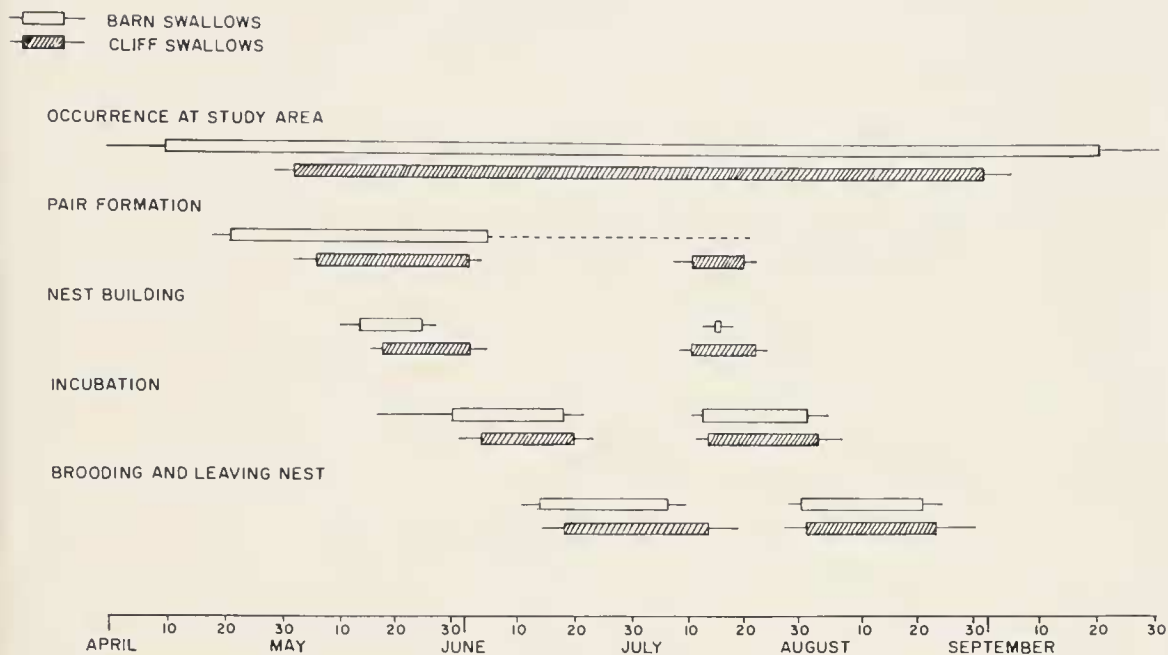


FIG. 1. Reproduction cycle of Barn and Cliff Swallows, 1967. Lines represent durations of activity in time; bars show peak periods of activity; dashed line shows uncertain dates. Sample sizes for Barn Swallows during the following periods are: nest building, 9 first clutch nests, 4 second clutch nests; incubation, 40 first clutches, 10 second clutches. Sample sizes for Cliff Swallows during the following periods are: nest building, 10 first clutch nests, 9 second clutch nests; incubation, 5 first clutches, 6 second clutches.

nesting populations. Barn Swallow nests used for first clutches totaled 58 in 1967 and 50 in 1968. As some birds laid a first clutch during the second clutch period, the population estimate for Barn Swallows was probably low.

Cliff Swallow counts included nests at least seven-eighths complete and totaled 40 in 1967 and 39 in 1968. Since Cliff Swallows sometimes build two to three nests per season, the population estimate may be high. If these variables were similar for both summers, the population was stable.

Nest-site Selection.—The essential features of the nesting sites of Cliff Swallows include: 1) open foraging areas, 2) vertical substrate with overhang for nest attachment, and 3) mud for nest construction (Emlen, 1954). This study revealed another requirement for a Cliff Swallow nesting in the interior of a barn: a sufficiently wide entrance. Most barns had wide entrances, but all were not open during successive years. Only two of nine Cliff Swallow nest sites had entrances less than 8 by 8 feet, and when such entrances were even partially closed, Cliff Swallows abandoned the nest. Barn Swallows under similar circumstances did not abandon their nests; they used any opening, large or small, for entrance. Otherwise, requirements for the nest site were similar for both species. Cliff Swallows and Barn Swallows nested

1968

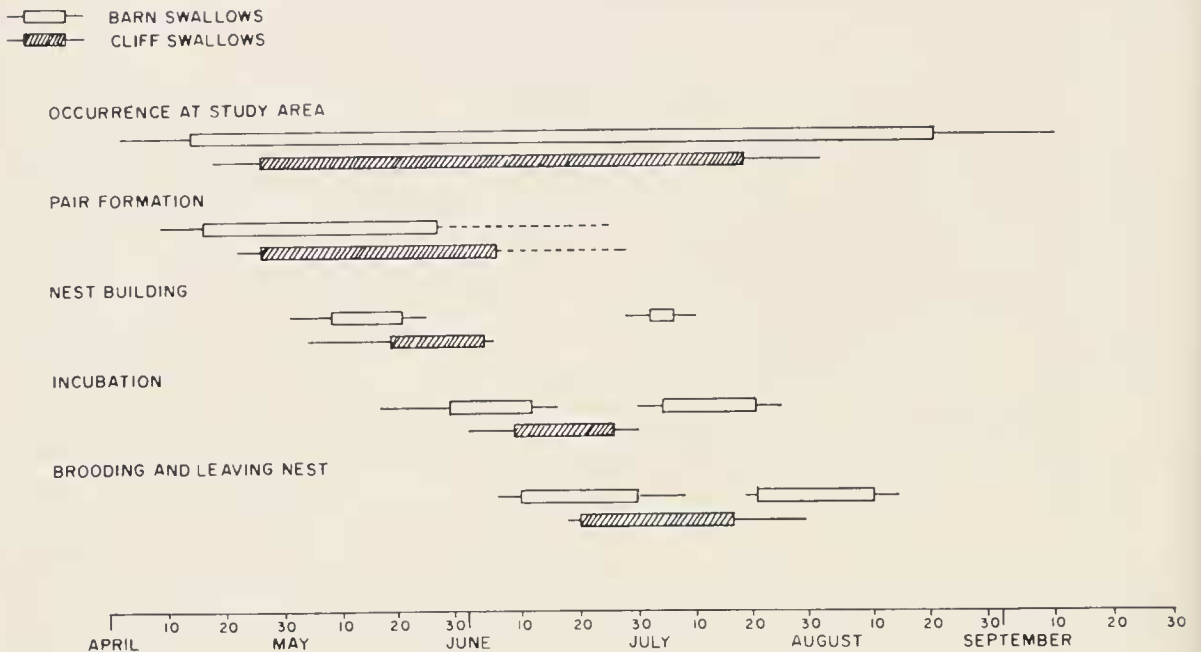


FIG. 2. Reproductive cycle of Barn and Cliff Swallows, 1968. Lines represent durations of activity in time; bars show peak periods of activity; dashed line shows uncertain dates. Sample sizes for Barn Swallows during the following periods are: nest building, 9 first clutch nests, 6 second clutch nests; incubation, 28 first clutches, 12 second clutches. Sample sizes for Cliff Swallows during the following periods are: nest building, 7 nests; incubation, 27 clutches.

together in numbers only once, but Cliff Swallow nest marks were found in 85 per cent of 32 barns and 18 sheds examined in Preston County.

Once a site was used, adults continued to return to the same building. Of the seven adults banded in 1967 and recaptured in 1968, all were retaken in the same barn. Two birds banded as nestlings in 1967 at barn 10 and shed b. returned in 1968 to barn 8. Groups of 10–30 juvenile Barn Swallows were commonly seen at the barns prior to the fall migration. I do not know whether their nest sites were selected then, or the next spring. No Cliff Swallows banded in 1967 were recaptured in 1968.

Pair Formation.—The breeding behaviors of the two species, particularly pair formation and copulation, were different. In March, 1968, Barn Swallows were observed in South Carolina and Georgia. Thirty-one of 33 were perched alone indicating non-pairing; however, most Barn Swallows on the study area were paired within 2 weeks after arrival. Pair formation took place on fences and lines located around the nesting area. Daily activities at barns were interrupted every 30–40 minutes by 10–15 minute periods of group feeding. Groups flew in and out of barns, fed, and perched. Paired birds were frequently challenged by unpaired birds; perching or flying between them.

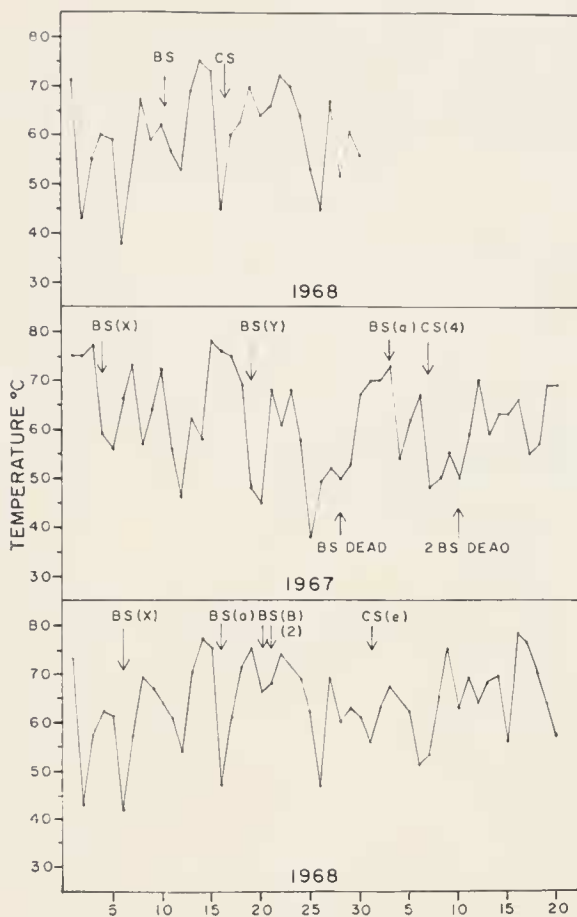


FIG. 3. Maximum daily temperatures and arrival times for Barn Swallows (BS) and Cliff Swallows (CS). At the top, data from one barn on area B for 1968 is shown, while the middle and bottom contain data collected on area A in 1967 and 1968. (X) and (Y) are barns near area A. (a), (e), (2), (4), and (8) are barns and sheds on area A.

Unpaired birds, however usually perched alone, and sang frequently, especially when other birds flew near. On cold days (35° – 45°), Barn Swallows fed over ponds and did not return to the barns for 2–3 hour periods.

Cliff Swallow pair formation began upon arrival. It took place at or in the nest and in close proximity to other individuals, while pair formation of Barn Swallows did not. The behavior of Cliff Swallows was similar to that described by Emlen (1954). Pairing was also seen in three flocks of birds which arrived at the study area in July. One flock contained three marked females, of which two had had unsuccessful nests and one had successfully reared a brood at nearby barns. These birds did not have the same mates in the second pairing; all three participated in nest-building and one laid a second clutch.

Nest-building.—Barn Swallows build adherent or statant nests. The less common statant nests (Table 1, A and B) have an under support, while

TABLE 1
NEST OBSERVATIONS FOR BARN SWALLOWS AND CLIFF SWALLOWS ON ALL STUDY AREAS
IN 1967 AND 1968.

	1967	1968	Totals
Barn Swallow			
A. Statant nests	32	12	44
B. Adherent nests	74	21	95
C. Nest used for both clutches	9	10	19
D. New nest for 2nd clutch	7	0	7
E. Swallows in 1968 reusing nests from 1967	—	35/62*	—
F. Swallows in 1968 using nests built previous to 1967, and unused in 1967	—	11	11
G. New nests in 1968	—	13	13
H. Nests used in 1967, not in 1968	27	—	27
Cliff Swallow			
a. Swallows in 1968 reusing nests from 1967	—	18/48**	—
b. New nests in 1968	—	25	25

* Birds reused 35 of 62 nests used in 1967.

** Birds reused 18 of 48 nests used in 1967.

adherent nests are attached only to vertical surfaces. Only the adherent gourd-shaped type of Cliff Swallow nest is found.

Barn Swallows were observed building nests on four occasions, and both sexes participated. Mud was gathered close to the barn, usually from wet areas trampled by livestock outside the entrances. Birds landed and, with wings folded in the normal position, collected mud in the beak. Both birds took turns about every 5 minutes adding mud to the nest. When the base was completed, birds perched on it to add more mud. Barn Swallows embedded horse hair, if available, into the nest as it was constructed. Feathers lined the nest and occasionally feathers were carried to the nest after eggs were laid. The presence of chicken feathers below indicated an active nest.

Only once were Barn Swallows and Cliff Swallows seen gathering mud together. Mud gathering was not a social activity in Barn Swallows. Nest building was an independent pair activity, and no mud was added to the nest of another pair.

Mud gathering by Cliff Swallows was a social activity and, once begun, was joined in by many birds. Mud was obtained up to 100 yards from the nest site, from farm ponds or rain puddles. Marked birds used different puddles or different places around a pond or puddle, and seldom returned to the same spot twice in succession. Birds from different farms (colonies) were never seen

gathering mud together from the same place. Each farm usually had a nearby source of mud. Cliff Swallows fluttered their wings high above their backs as they pecked at the mud until a pellet was collected. Occasionally a bird swiped its bill upward, also, collecting mud on top of the beak. Unpaired birds might bring pellets to nests and paired birds with completed nests sometimes added to adjacent nests. Both members of a Cliff Swallow pair participated and exchanged places at the nest with each trip. Once incubation started, nest repairs were made by both sexes.

The structure and construction of the Cliff Swallow's nest was similar to that of the Barn Swallow until the roof was placed over the cup. Cliff Swallows lined the bottom of the nest with pieces of straw or hay, rather than with feathers. Barn Swallows did not lay eggs in unfinished nests but Cliff Swallows commonly did so.

Not all birds build new nests. Barn Swallows nesting on the study areas in 1968 reused 35 of 62 nests used in 1967 (Table 1E) and 11 pre-1967 nests (Table 1F). Most birds added mud to the nest rim and cup, so that the whole structure might reach a height of over 12 inches after years of use. Occasionally the greater portion of the old nest was rebuilt. Thirteen new Barn Swallow nests were built in 1968 (Table 1G).

Cliff Swallows reused old nests (Table 1a) or rebuilt nests entirely (Table 1b). Most Cliff Swallow nests were destroyed during the winter and had to be rebuilt. In 1968, more than one-half of all Cliff Swallows on the area nested in one barn where 1967 nests remained.

Barn Swallows rarely build nests within 5 feet of an entrance, but if so they may use old Cliff Swallow nest-marks as a base. However, 89 of 90 Cliff Swallow nests were built on one of three girders nearest the barn door.

Barn Swallows began nest building before Cliff Swallows (Fig. 1). The average building time for 18 adherent Barn Swallow nests was 6.4 days (range 3–10). Building time for 17 Cliff Swallow nests constructed during May and June averaged 13.0 days while 9 nests built during July for a second brood or by those unsuccessful at first nests took an average of 8.4 days to complete.

Incubation.—The eggs of both species were laid on consecutive days until clutch completion. Intermittent incubation began after two or three eggs were laid and became continuous the day before the last egg was laid. Incubation time was measured from the day the last egg was laid until the day the last young hatched. Incubation time for five Barn Swallow nests was 15 days and for seven Cliff Swallow nests was 15 days.

In most Barn Swallow nests where at least one member of the pair was marked and sexed, only the female incubated. However, male Barn Swallows assisted in incubation at four nests. Barn Swallow nest-attentiveness re-

TABLE 2
NEST ATTENTIVENESS OF BARN AND CLIFF SWALLOWS DURING INCUBATION.

	Days	08:30-11:30		11:31-14:00		14:01-16:30	
		Time	%	Time	%	Time	%
Barn Swallows	0-4	95	55.4	105	74.0	70	85.7
	5-9	84	47.2	98	63.2	91	38.0
	10-15	—	—	68	19.2*	135	14.7*
Cliff Swallows	0-4	—	—	40	95.0	40	100.0
	5-9	58	72.2	67	91.3	58	98.3
	10-15	104	73.1	—	—	—	—

Time = Total minutes of observation during this time period.

% = Percentage of time male or female was on the nest.

* Biased low as observations were made on day 15 at one nest when two of five eggs had hatched.

mained relatively stable during the incubation period, except for the morning period (Table 2).

Observations of 11 marked pairs showed that male Cliff Swallows incubated regularly. When a pair was observed 4 days after incubation began, the male entered the nest once and the female three times during a 40-minute period. On the fifth day, the male entered the nest four times and the female nine times during a 67-minute period. The birds usually exchanged places, with the male in the nest 63 of 80 minutes, the female only 42 of 80 minutes. Upon entering, the male moved into the lower part of the nest and assumed the same position as the female. During the incubation period with at least one member of a pair was usually incubating (Table 2).

Clutch Size and Hatching Success.—For Barn Swallows a first clutch of five eggs was most common while a second clutch of four was most common (Table 3, Fig. 4). More than six eggs per nest may indicate dual laying for Barn Swallows (Mason, 1953); however, seven eggs were found in three nests occupied by single females. From clutches of six eggs, 77 per cent of the eggs hatched; from clutches of five, 82 per cent; from clutches of four, 83 per cent; from clutches of three, 85 per cent; and from clutches of two, 87 per cent. Twenty-seven Barn Swallows of 33, that raised second broods, used old nests, though eight of these changed nests between clutches.

For Cliff Swallows a first clutch of four eggs was most common, while a second clutch of three was most common (Fig. 4).

Brooding and Nestling Mortality.—The period from hatching until leaving the nest averaged 20.7 days (range 18-27 days) for 10 Barn Swallow broods. The time from the first egg until the birds left the nest was 36-47 days. No difference was found for second broods.

TABLE 3

CLUTCH SIZE, EGG LOSS, NESTLING MORTALITY AND TOTAL MORTALITY FOR BARN AND
CLIFF SWALLOWS, 1967 AND 1968.

Barn Swallows		Cliff Swallows	
First Clutch	N = 94	First Clutch	N = 35
Avg. Clutch Size =		Avg. Clutch Size =	
430/94	4.57 ± 0.11	116/35	3.31 ± 0.30
Egg Loss = 72/430	16.7%	Egg Loss = 37/116	31.9%
Total Egg Loss =		Total Egg Loss =	
91/564	16.1%	50/142	35.2%
Nestling Loss =		Nestling Loss =	
9/358	2.5%*	2/79	2.5%*
First Clutch Mortality =		First Clutch Mortality =	
81/430	18.8%	39/116	33.6%
Second Clutch	N = 33	Second Clutch	N = 9
Avg. Clutch Size =		Avg. Clutch Size =	
134/33	4.06 ± 0.29	26/9	2.89 ± 0.15
Egg Loss = 19/134	14.2*	Egg Loss = 13/26	50.0%
Nestling Loss =		Nestling Loss =	
1/115	0.9%*	7/13	53.8%
Second Clutch Mortality =		Second Clutch Mortality =	
20/134	14.9%	20/26	76.9%
Total Mortality, Both Clutches =		Total Mortality, Both Clutches =	
101/564	17.9%	59/142	41.5%

N = Sample size; average clutch size ± one standard deviation.

* This figure is lower than the real value because a few dead nestlings were probably not discovered.

The period from hatching until leaving the nest averaged 23.6 days for six Cliff Swallow broods. The total time from the first egg until the birds left the nest ranged from 33–48 days.

First-brood nestling mortality for Barn Swallows was 2.5 per cent, while second-brood nestling mortality was 0.9 per cent (Table 3). Cliff Swallow nestling mortality for first broods was also 2.5 per cent, but 53.8 per cent of the nestlings in second broods died. Total mortality for all Barn Swallow eggs laid was 17.9 per cent, compared to 41.5 per cent for Cliff Swallows.

Nest attentiveness in both species decreased as nestlings grew older. After 15 days, nestlings were brooded very little, especially on warm days. At night female Barn Swallows remained on the nest with the male perched beside it, while both the male and female Cliff Swallows remained in the nest.

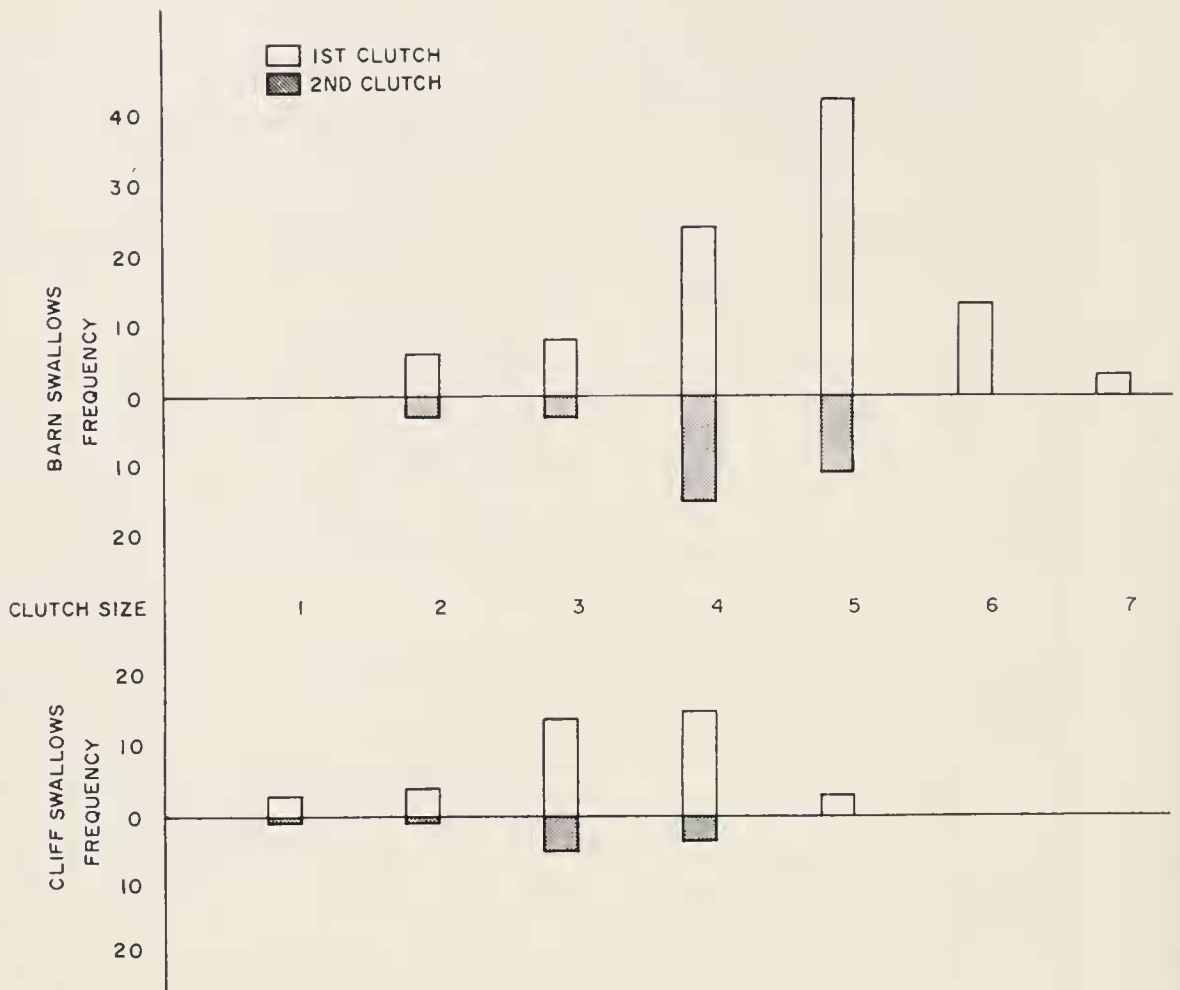


FIG. 4. Clutch sizes of Barn and Cliff Swallows.

Males of both species fed nestlings (Table 4). Male Barn Swallows fed nestlings as often as did females with the sexes exchanging places at the nest with each feeding. Cliff Swallows exchanged places also, and vocalizations announced each arrival and departure. Once nestlings could fly, they perched in family groups on telephone lines and fences. Adults fed the young on the wing and while perching beside them. Within a week, juveniles fed with the parents. Later, they joined adults in large feeding flocks.

Behavior Prior to Second Broods.—Barn Swallows which raised second broods exhibited courtship behavior. Courtship songs were heard, although pairs were established and appeared unchanged. After 29 May 1968, a Barn Swallow mount produced no copulation attempts as it had earlier in the year, indicating that the birds were paired. "Song flights" were seen between broods. These "flights" lasted 15–20 minutes and consisted of a flock of adult Barn Swallows from one barn flying quite high, chasing, and giving occasional songs. Juveniles were seen in such flocks. Between broods Barn

TABLE 4

FEEDING RATES FOR NESTLING BARN SWALLOWS AT FOUR NESTS AND CLIFF SWALLOWS
AT THREE NESTS.

Stage of Brooding	Time	Nest Visits
Barn Swallow		
early	38	Male - - - - - 10
		Female - - - - - 9
late	23	Male - - - - - 11
		Female - - - - - 11
late	15	Male - - - - - 9
		Female - - - - - 4
late	21	Male - - - - - 9
		Female - - - - - 6
Cliff Swallow		
early	14	Male - - - - - 20
		Female - - - - - 12
early	129	Male - - - - - 20
		Female - - - - - 12
late	55	Male - - - - - 15
		Female - - - - - 18

Time = Total minutes of observation during brooding. Early brooding = 1-7 days, late brooding = 8-15 days. Nest visits = a feeding.

Swallows added small amounts of mud to the nest rim and more chicken feathers to the nest.

Cliff Swallow courtship behavior and associated vocalizations were evident between broods. A Cliff Swallow mount was ignored, indicating that pairs were intact.

Altered Activities.—Nest-building, incubation, and brooding activities were disrupted by milking activities at the farms. Some farmers milked before daylight, causing birds to leave the barn. Nest-building in Cliff Swallows began in most barns around mid-morning following perching activities. However, at one barn milking was delayed until mid-morning and nest-building was delayed until the noon period.

Evening milking was also disruptive for both species. Birds entered the barn at dusk; but, at the one barn where milking was delayed until dark, birds were forced to perch outside. Such interruptions altered activities, but did not cause nesting delays or abandonments.

TABLE 5
LIFE EQUATION OF 100 BARN SWALLOWS FOR A YEAR.

Time	Activities	Number of Barn Swallows	
		Young	Adults
Spring	(1) 50 males, 50 females		100
	(2) Females nest, avg. 4.57 eggs $50 \times 4.57 = 228$ eggs laid		
	(3) 16.7 per cent eggs do not hatch = 38 $\therefore 228 - 38 = 190$ eggs hatch		
Summer	(4) 2.5 per cent die before leaving nest = 5	185	
	(5) 35.2 per cent of 50 females lay a second clutch, avg. 4.06 $18 \times 4.06 = 73$ eggs laid		
	(6) 14.2 per cent eggs do not hatch = 10 $\therefore 73 - 10 = 63$ eggs hatch		
	(7) 0.9 per cent die before leaving nest = 1	62	
	(8) Total number of young leaving the nest to migrate in the Fall	247	
	(9) Approximately 2 males and 2 females die during Spring and Summer		96
Fall-Winter	(10) An estimated 60 per cent of the adults die from time of migration South until they arrive in the Spring = $96 \times 0.60 = 58$		38
	(11) 74 per cent of 247 young die from Fall to Spring (Mason, 1953) = $185, 247 - 185 = 62$		62
	(12) Spring population		100

Life Equations.—The life equations proposed for Barn and Cliff Swallows (Tables 5 and 6) assume a stable population. Almost certainly there are population fluctuations for these species from year to year, but these probably balance out for Barn Swallows. It is not known whether Cliff Swallow populations are stable or decreasing but the latter possibility exists.

Post-Brooding Activities.—Cliff Swallows left the area 2–4 weeks before Barn Swallows (Figs. 1 and 2). All of the Cliff Swallows in each barn departed simultaneously. However, Barn Swallow flocks moved through the area sporadically until late September. Their departure was not simultaneous and birds with young remained in the area until their nestlings became independent.

Nest Abandonment.—Samuel (1969b) described the factors causing nest

TABLE 6
LIFE EQUATION OF 100 CLIFF SWALLOWS FOR A YEAR.

Time	Activities	Number of Cliff Swallows	
		Young	Adults
Spring	(1) 50 males, 50 females		100
	(2) Females nest, avg. 3.31 eggs $50 \times 3.31 = 165$ eggs laid		
	(3) 31.9 per cent eggs do not hatch = 52 (See Samuel, 1969b) $\therefore 165 - 52 = 113$ eggs hatch		
Summer	(4) 2.5 per cent die before leaving nest = 3	110	
	(5) 26.7 per cent of 50 females lay a second clutch, avg. 2.89 $13 \times 2.89 = 38$ eggs laid		
	(6) 50 per cent eggs do not hatch = 19 (See Samuel, 1969b) $\therefore 38 - 19 = 19$ eggs hatch		
	(7) 53.8 per cent die before leaving nest = 10	9	
	(8) Total number of young leaving the nest to migrate in the Fall	119	
	(9) Approximately 2 males and 2 females die during Spring and Summer		96
Fall-Winter	(10) An estimated 50 per cent of the adults die from time of migration South until they arrive in the Spring (Mayhew, 1958) $= 96 \times 0.50 = 48$		48
	(11) An estimated 65 per cent of 119 young die from Fall to Spring $= 77, 119 - 77 = 42$		42
	(12) Spring population		100

abandonment in Cliff Swallows. These included barn alterations, House Sparrows (*Passer domesticus*), and fallen nests.

Barn alterations included "the closing of a door or window used as an entrance way, the placing of farm animals in an area beneath the nest, or any building or structural alteration near the nests."

Neither House Sparrows nor barn alterations caused disturbance to Barn Swallows, which entered the barns through small openings and continued nesting.

One pair of marked Barn Swallows that had begun building moved outside when cows were placed under the nest. This pair remained in the area of their nest for two days, but on the third day began a new nest in a nearby shed. They raised two broods here.

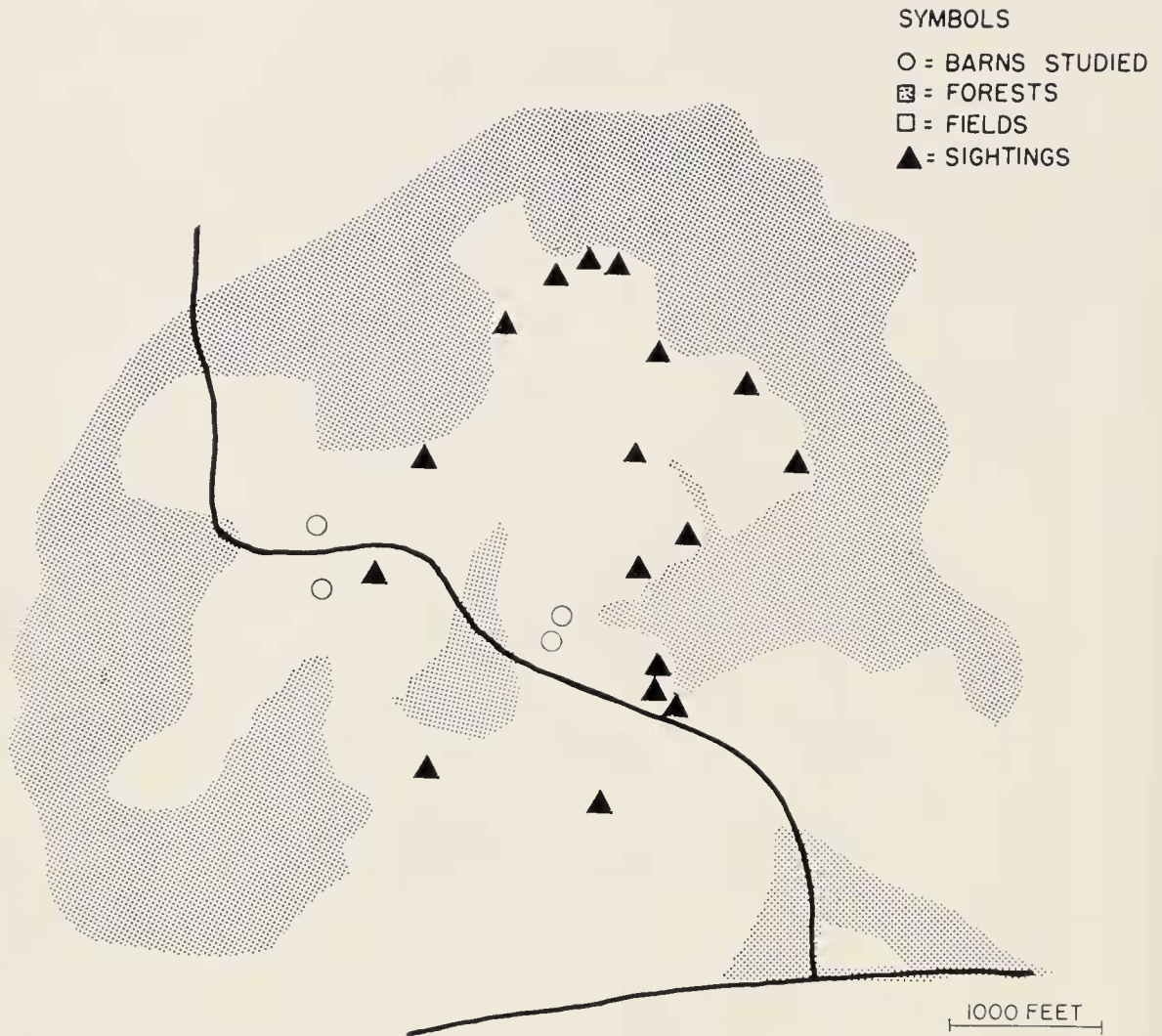


FIG. 5. Foraging area of a marked pair of Barn Swallows. Area is based on 17 sightings during one week. Birds rested in two barns in center.

Interspecific Relations.—I found nine Cliff Swallow nests built on top of Barn Swallow nests. Four of these were used by both species during one season, but no direct interactions between individuals were observed. Barn Swallows successfully reared broods before the arrival of the Cliff Swallows. Cliff Swallows disrupted normal nesting activities of only a few Barn Swallows.

Twice, Barn Swallows nested in incomplete and abandoned Cliff Swallow nests. On four occasions, Barn Swallows nested in old Barn Swallow nests previously used by Cliff Swallows, from which the tops had fallen away. Barn Swallows did not disturb Cliff Swallow nesting.

Four times Barn Swallows were seen flying into buildings where only Cliff Swallows nested; twice they were chased by Cliff Swallows and both times they left quietly. A Cliff Swallow was chased from a barn by a Barn Swallow on one occasion. No interactions were elicited by Barn Swallows

flying under Cliff Swallow nests to reach their own nests. Both species were chased by House Sparrows using Cliff Swallow nests.

Feeding and Perching.—Where both swallow species occurred, they rarely fed and perched together. Cliff Swallows spent more time feeding above 100 feet, while Barn Swallows fed over ponds and fields. The feeding areas of the two species were thus vertically stratified and suggested a difference in diets.

Barn Swallows had smaller foraging areas (Fig. 5). Typically, the foraging range of Barn Swallows followed the borders of wooded areas within $\frac{3}{4}$ mile of the nest. The foraging areas of Cliff Swallows were larger, but no exact data were collected. Emlen (1952) reported Cliff Swallows foraging 2 miles from the colony site.

Cliff Swallows rarely perched on low barbed wire fences, as Barn Swallows regularly did. Conversely, no Barn Swallows perched on the 100-foot power lines used by Cliff Swallows. However, both perched on telephone lines of 30-foot height.

Both species fed and perched with other swallow species. During spring migration Barn Swallows associated with Tree Swallows (*Iridoprocne bicolor*). During nesting Barn Swallows and Rough-Winged Swallows (*Stelgidopteryx ruficollis*) were seen together around barns when the latter nested nearby. During spring migration Cliff Swallows perched or fed with Bank Swallows (*Riparia riparia*). Cliff Swallows displaced perching Bank Swallows on three occasions, but for the most part these two species appeared to be compatible.

DISCUSSION

The differences in arrival time between the two species may be a result of different migration routes. Lincoln (1950) postulated that Cliff Swallows migrate through Central America and Mexico and then into the United States, while the Barn Swallows apparently migrate across the Caribbean Sea to Florida and then north and west (Sprunt, 1954). These routes would explain the difference between the dates for West Virginia and those given by Moody (1968) for these species in the state of Washington, where the Cliff Swallow arrived before the Barn Swallow. The differences in arrival times might also be explained by differences in wintering areas.

Barn Swallow and Cliff Swallow arrival almost always followed a warm period. This is not surprising since arrival of most species of swallows is correlated with mean temperature or daily maximum temperature. Occasionally the earlier arriving Barn Swallow may suffer from late cold weather. Bell (1962) presents the interesting idea that first-year Barn Swallows arrived late and this may preserve the species in case of an early high mortality.

Overlap in breeding season occurred for these species in West Virginia.

Moody (1968) found little overlap in the breeding seasons of Barn and Cliff Swallows in Washington and postulated that this difference in timing evolved as a result of interspecific competition. My observations show that competition would not cause evolution of different nesting times. For example, little competition occurs during the initial phases of nest building. The mud-gathering habits of Barn and Cliff Swallows differ widely. Cliff Swallows always build near entrances while Barn Swallows build nests deeper within the barns. Occasionally Cliff Swallows built on top of an active Barn Swallow nest, but such competition was not serious and only involved nests located near an entrance, where Barn Swallows seldom built.

Moody (1968) observed Cliff Swallows in Washington building on Barn Swallow nests before the Barn Swallows arrived. He postulated that if Cliff Swallows continue to arrive first and construct their nests under the bridge (on Barn Swallow nests), the Barn Swallow may eventually be replaced at the colony site. However, since Barn and Cliff Swallows, in both Washington and West Virginia, build in slightly different areas of bridges and barns, such interactions are not due to competition but to population overflow and chance. Basic differences in the nest site selection make it doubtful that Cliff Swallows would thus replace Barn Swallows.

Competition for food could influence the evolution of non-overlapping nesting cycles but this was not observed. If food were a limiting factor, nestling mortality due to starvation would be expected, as would intraspecific competition. Neither was evident.

Barn Swallow pair formation took place on fences around the barn, and not in the area of the nest as with Cliff Swallows. Emlen (1954) previously described the first step in pair formation of Cliff Swallows as hovering of birds near the nests, and this continued from the earliest breeding activity until first nests were nearly completed. Hovering also occurred later in the form of "raiding behavior." Emlen (1952) believed that these raiding groups were composed of non-breeding birds after the destruction of their nests in a neighboring colony. A "raiding" flock arrived on the study area in July 1967, and exhibited pair formation behavior. This flock contained; a) 50-60 adults and 10-15 juveniles, b) a marked female which reared one brood at another barn and then built a nest at the new colony site, c) two marked females which had had unsuccessful nests at least twice previous to their arrival at this new colony. Thus, it appears that in the west raiding flocks are composed of non-breeders but in the east such "transient" groups are more heterogeneous.

I found only 35 per cent of the swallows raised second broods, and 27 of these 33 were from reused nests. It would appear that Barn Swallows which reuse or rebuild on old nests have a better chance to raise second broods. Bent

(1942) and McCann (1936) believed that Cliff Swallows raised two broods, while Buss (1942) stated that what appeared to be second broods were really re-nesting birds whose first nests were destroyed. A flock of birds which arrived at one shed on 10 July 1967, contained 3 re-nesting females and one of these raised a second brood.

The fledgling period of Cliff Swallows is 3 days longer than that of Barn Swallows. The Cliff Swallow nest is gourd-shaped and the entrance is a small hole. Lack (1968) suggested that hole-nesting Passerines have evolved longer fledgling periods, and can thus raise more young in a brood. Another interpretation of this longer fledgling period might be that swallows are similar to swifts; the species which feed higher above the ground find less food, producing a longer fledgling period (Lack, 1968).

The second clutch mortality of Cliff Swallows was 50.0 per cent; twice as great as first clutch mortality. High second brood mortality in Cliff Swallows was also reported by Foster (1968) in California where Cliff Swallows departed together as a colony and leave eggs and nestlings. This occurred at one barn during this study. Barn Swallows did not abandon nests until the breeding cycle was complete, regardless of when other pairs migrated.

The effect of the introduced House Sparrows on Cliff Swallow populations can only be surmised, without a long-term study. During this study I noted that House Sparrows caused many Cliff Swallows to abandon their nests (Samuel, 1969*b*).

Barn Swallows are much better adapted to nesting inside barns because farmers destroyed fewer of the less conspicuous nests, and closed doors did not cause nest abandonment. In view of their high mortality, one wonders why so many Cliff Swallows nest inside barns and sheds in the East rather than outside under eaves as they habitually do in Wisconsin (Aumann and Emlen, 1959). Forbush and May (1939) suggested that an increase in the number of painted barns in the east caused a decrease in Cliff Swallows because the nests would not adhere to the barns. This might cause birds to nest inside where unpainted substrates were available. Yet most barns in the midwest are painted and most swallows still nest under the eaves. There also may be some unknown relation between nesting inside and the low numbers of birds on the study area. Many colonies in the west and midwest contain hundreds of birds, and these birds usually nest outside.

SUMMARY

Barn and Cliff Swallows both may be found nesting inside the same, or neighboring barns or sheds in West Virginia. However, though apparently similar the two niches were found to be separable, and no competition was observed.

From arrival through nest building, differences in the breeding biology of these two species were found. Barn Swallows arrived in mid-April, while Cliff Swallows

arrived in late April or early May. Pair formation in both species occurred in different areas around the barns.

The requirements for a nesting situation are similar, except that Cliff Swallows entered only wide doors (8 × 8 feet) while Barn Swallows utilized any small opening as an entrance. Barn Swallows gathered mud near the barn entrances, while Cliff Swallows utilized the farm ponds and rain puddles where they occurred. Neither species traveled more than 100 yards to obtain mud.

Barn Swallows build adherent and statant nests on girders scattered throughout the barn. Cliff Swallows build gourd-shaped nests immediately inside the entrance. In 1968, Barn Swallows reused 35 of the 62 nests used in 1967. Most Cliff Swallow nests fell down or were removed by the farmer during the winter of 1967, and had to be rebuilt in 1968. The average building time for 18 adherent Barn Swallow nests was 6.4 days, while 17 Cliff Swallow nests took 13.0 days to build.

Incubation time for both species was 15 days, but other aspects of raising young differed. Male Cliff Swallows incubate more regularly than male Barn Swallows. First clutches of Barn Swallows averaged 4.6 eggs, while second clutches averaged 4.1 eggs. Total mortality for both clutches was 17.9 per cent. First clutches of Cliff Swallows averaged 3.31 eggs. Nine second clutches averaged 2.89 eggs, while total nest mortality was 41.5 per cent.

Barn alterations, i.e., closing doors after hay was brought in, etc., did not markedly affect Barn Swallow nesting, but caused abandonment of Cliff Swallow nests. House Sparrows did not interfere with Barn Swallow nests, but caused high Cliff Swallow nest losses.

Basic differences occurred in feeding and perching for these species. Cliff Swallows fed at a higher altitude and foraged as much as two miles from the nest site, while Barn Swallows fed lower and seldom more than one-half mile from the nest site. Barn Swallows commonly perched on low fences, while Cliff Swallows were seen perched on higher power lines.

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